

# Emerging Nuclear Innovations: Picking Global Winners in a Race to Reinvent Nuclear Energy

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# The Other Skypes and Google –

- -Uranium modular
- -Uranium molten salt
- -Fast Neutrons
  - Bill Gates/TerraPower
  - General Atomics
- -CHINA
- -Pebble Bed
- -**Fusion**

# FNR - Bill Gates' TerraPower

- - **Not modular, at least not at first.**
- -Will use depleted uranium
- -No reprocessing necessary. -Plutonium breeds and burns in-situ.
- - Terra says there's a 100 year supply of the stuff.
- -Liquid sodium cooled
- -Working with Idaho U.S. National Laboratory and others.
- - Casting about for development deals in Russia, China, India
- - India's Reliance Industries has since invested.
- -**But won't have a reactor in place until 2030.**
- - **TERRA SAYS ITS REACTOR COULD RUN ON THORIUM. BUT IT'S DESIGNING FOR URANIUM.**

# FNR - General Atomics

- **Modular.** 240 megawatts. As much for industrial heat as for electricity.
- -It's called the Energy Multiplier Module, or EM2.
- -Will use depleted AND spent fuel. GA says there's enough of the 2 to equal 40 Saudi Arabia's worth of oil, or 9 trillion barrels.
- -Fuel lasts 30 years..
- - High temperature, 850 degrees C, efficient
- - Helium gas cooled.
- - Requires fuel processing , unlike TerraPower. **BUT does not require fuel reshuffling.**
- - And it is deploying a so-called safe reprocessing technique based on physical, dry extraction.
- -3 to 4 years for basic research, 10 years to complete a prototype, all for about \$3 billion of development
- . Prototype might go at the Savannah River site, South Carolina.
- - First EM2 commercial reactor by 2025-2030.

# FNR - China

- -Conventional nuclear will level off at 200 gigawatts around 2040
- -FNRs will then take over and hit 200 gigawatts by 2050 and 1,400 gigawatts by turn of century
- -Connected the small, test Chinese Experimental Fast Reactor to grid last year
- -Will begin building two larger scale (around 800-900 MW) FNRs by 2013, based on Russian designs, operating by 2019
- -Will begin building a 1 GW FNR OF ITS OWN DESIGN in 2017, operating by 2020.
- China National Nuclear Corp has talked with Bill Gates about joint development

# Pebble Bed

- -Gas cooled
- -QPower in South Africa has picked up where the South African government left off. Helium-cooled.
- - Could possibly use thorium, maybe uranium.
- -30 MW modular
- -Qpower might build in U.S., where DOE has given some priority to gas cooled reactors in its Next Generation Nuclear Plant initiative.

# Modular

- -It's the heat, plus remote regions that use diesel for electricity.
- -Oil sands.
- -Radix, using TRIGA fuel, 10 MW reactor. One market - frontline bases, Afghanistan. But: They did not get DARPA funding.
- -Nuscale,
- -Hyperion
- -Fusion

# China

- -Could build as many as 100 reactors by 2030
- -It's going for all sorts of nuclear.
- -Nuclear today 1.8% of China's electricity
- -27 reactors under construction now - conventional.
- -Over 100 nuclear companies.
- -One company, China National Nuclear Corp alone investing .Investing \$120 billion in nuclear through 2020
- -CNNC has over 100,000 employees, possibly 200,000



# China - Thorium

- -Tsinghua University's INET group investigating various possible uses of thorium including its use in a heavy water reactors at the Qinshan site.
- -China Academy of Sciences developing a thorium molten salt reactor
- - An accelerator style thorium reactor.
- Developing an accelerator style thorium reactor.

# China - Pebble Bed

- - China currently building a demonstrator at the Shidaowan facility in Shandong.
- - Plans 18 more.
- - Each around 210 watts capacity.

# Fusion

- If fusion is 30 years away, why are VCs investing?
- Startups will get there first, before the government funded behemoths like ITER and NIF.

# Fusion - 'Conventional'

- **Deuterium/Tritium**
- General Fusion, Burnaby , Canada, has raised \$32 million, including from Jeff Bezos and from a Canadian oil company Cenovus.
- Helion Energy, Redmond, Wash.

# Fusion - 'Unconventional'

- **Aneutronic**
- **Eliminates turbines. Creates electricity directly through charged particles.**
- Does NOT rely on hot escaping neutrons.
- Tends to fuse hydrogen and boron.
- Much hotter 1-to-2 billion degrees versus 100 million to 150 million for 'conventional' fusion.
- Tri-Alpha, Irvine, Calif., has raised over \$140 million in venture funds, including from Goldman Sachs.
- Lawrenceville Plasma Physics, New Jersey. **Partnering with Iran. 'Fusion for Peace' initiative.**

# Thorium Challenges

- Opponents say thorium is not wonderful as made out to be on proliferation.
- Why mine thorium when you can run reactors on spent fuel and depleted uranium?
- Renewables,
- Fracking
- Conventional nuclear, including modular
- CHINA
- CHINA
- CHINA
- China also an opportunity.

# How to tell me you're saving the planet

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